New POPs – The unique challenge of controlling PBDEs under the Stockholm Convention

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Introduction

In May 2009 certain congeners contained in commercial pentabromodiphenyl ether[1] ('PentaBDE') and octabromodiphenyl ethers[2] ('OctaBDE') were added to Annex A of the Stockholm Convention[3] by the fourth Conference of the Parties in Geneva. As a consequence of this these chemicals are officially recognised as persistent organic pollutants ('POPs') and may no longer be produced. Furthermore Article 6 of the Convention requires that wastes containing POPs be managed in a manner protective of human health and the environment (Stockholm Convention 2001). The new listing therefore requires each party of the Stockholm Convention to take appropriate measures to reduce or eliminate releases of persistent organic pollutants (POPs) from stockpiles and wastes.[4]

The listing of these PBDEs[5], unlike the original Stockholm POPs, includes specific exemptions allowing for recycling and the use in articles of recycled materials containing these chemicals (Textbox 1) (Stockholm Convention 2009a,b). This exemption generated significant discussion about whether it could be considered to be consistent with the principal objective[6] of the Stockholm Convention which is to protect human health and the environment from persistent organic pollutants. Recycling of POPs inevitably increases the possibilities of generating new environmental and health risks. The possibility to include POPs in recycled products lead to exposure in the recycling stage (and future recycling cycles) and even generates the possibility that the 'second life' exposure may be greater than in previous uses. The long-term implications of allowing POPs to be released in what is likely to be an uncontrolled fashion also raises serious questions about whether the exemptions compromise the objectives of the Convention. The Persistent Organic Pollutants Review Committee was therefore requested to make recommendations to the Conference of the Parties to address the above concerns. These recommendations will be based on information gathered from Parties and observers, and informed by a technical report provided by external consultants.

The objective of this article is to highlight:

- the special issues that arise in relation to PBDEs and the Stockholm Convention – including the extent of the PBDE contamination problem.
- the areas where it will be necessary to do additional work, to review the knowledge gaps and to suggest how the science community could contribute to solving the problems.

Discussion

As there is no longer any (known) production of commercial PentaBDE or OctaBDE the main challenges relate to the identification and treatment of existing stockpiles.

While the product types in which PBDE have been used are (largely) known details of the extent of current and

1 The listing includes tetrabromodiphenyl ether and pentabromodiphenyl ether, meaning 2,2',4,4'-tetrabromodiphenyl ether (BDE-47, CAS No: 40088-47-9) and 2,2',4,4',5-pentabromodiphenyl ether (BDE-99, CAS No: 32534-81-9) and other tetrabromodiphenyl and pentabromodiphenyl ethers present in commercial pentabromodiphenyl ether.

2 The listing includes hexabromodiphenyl ether and heptabromodiphenyl ether, meaning 2,2',4,4',5,5'-hexabromodiphenyl ether (BDE-153, CAS No: 68631-49-2), 2,2',4,4',5,6'-hexabromodiphenyl ether (BDE-154, CAS No: 207122-15-4), 2,2',3,3',4,5',6 heptabromodiphenyl ether (BDE-175, CAS No: 446255-22-7), 2,2',3,4,4',5',6-heptabromodiphenyl ether (BDE-183, CAS No: 207122-16-5) and other hexabromodiphenyl and heptabromodiphenyl ethers present in commercial octabromodiphenyl ether. .

3 Decisions SC-4/14 on the listing of hexabromodiphenyl ether and heptabromodiphenyl ether and SC-4/18 on the listing of tetrabromodiphenyl ether and pentabromodiphenyl ether.

4 Article 6 of the Stockholm Convention.

5 For the purpose of the technical report, "PBDE" refers to certain congeners contained in commercial octabromodiphenyl and pentabromodiphenyl ethers as listed in decisions SC-4/14 and SC-4/18.

6 Article 1 of the Stockholm Convention

likely future recycling flows are less well quantified. A particular difficulty has been the lack of information about the historic production of PentaBDE and OctaBDE and quantified details of their respective uses. This is especially important for the United States and for China where large tonnages of PentaBDE and OctaBDE have been produced and used until recently. Products and wastes containing PBDE include certain plastic fractions and foams, used electronics and electronic waste and other second-hand goods including cars, busses, trucks, planes, carpets and textiles, etc. from these countries need to be evaluated for their PBDE contamination particularly when they are exported or recycled.

Exemptions for the recycling of articles

Decision SC-4/18 included specific exemption for use in articles in accordance with the following provisions:

1. A Party may allow recycling of articles that contain or may contain tetrabromodiphenyl ether and pentabromodiphenyl ether, and the use and final disposal of articles manufactured from recycled materials that contain or may contain tetrabromodiphenyl ether and pentabromodiphenyl ether, provided that:
   (a) The recycling and final disposal is carried out in an environmentally sound manner and does not lead to recovery of tetrabromodiphenyl ether and pentabromodiphenyl ether for the purpose of their reuse;
   (b) The Party does not allow this exemption to lead to the export of articles containing levels/concentrations of tetrabromodiphenyl ether and pentabromodiphenyl ether that exceed those permitted to be sold within the territory of the Party; and
   (c) The Party has notified the Secretariat of its intention to make use of this exemption.

At its sixth ordinary meeting and at every second ordinary meeting thereafter the Conference of the Parties shall evaluate the progress that Parties made towards achieving their ultimate objective of elimination of tetrabromodiphenyl ether and pentabromodiphenyl ether contained in articles and review the continued need for this specific exemption. This specific exemption shall in any case expire at the latest in 2030.

Decision SC-4/14 has substantially identical provisions in respect of hexabromodiphenyl & heptabromodiphenyl ether.

Textbox 1: Specific exemption for the recycling of articles containing TetraBDE to OctaBDE based on Stockholm Convention Decision SC-4/14 (Stockholm Convention 2009a) and SC-4/18 (Stockholm Convention 2009b).

To get a better understanding of the overall impact of PBDE in recycling schemes, the Conference of the Parties requested the Stockholm Convention Secretariat to collect the following information on brominated diphenyl ethers found in articles from Parties and observers[7] (Stockholm Convention 2009c):

(a) Types and quantities of articles containing brominated diphenyl ethers, including concentrations of those substances in the articles, including recycled articles;

(b) Types of articles recycled, the extent of recycling, the types of articles produced from recycling, the options for the environmental management of recycling operations and releases or potential releases resulting from recycling operations;

(c) Cost-effectiveness of different management options;

(d) Options for environmentally sound disposal;

(e) Methods for identifying the presence and levels of brominated diphenyl ethers in articles;

(f) Identification of remediation methods for contaminated sites as listed in subparagraph 1 (e) of Article 6 of the Convention;

(g) Any other related information.

For this process a questionnaire was developed to gather relevant information on these issues and sent to Stockholm Convention parties and observers.

Parties were sent a copy of the questionnaire on 20th November 2009 have been requested to provide responses and information by and interim deadline of 10th April with final information to be submitted by 1st July 2010. The information will then be compiled in a report along with other relevant information on

- Assessment of the possible health and environmental impacts of recycling articles containing brominated diphenyl ethers

[7] Pursuant to paragraphs 1–4 of the annex to decision SC-4/19.

- Identification of the best available techniques and best environmental practices for the recycling of articles containing brominated diphenyl ethers
- Review of the long-term environmental desirability of the recycling of articles containing brominated diphenyl ethers

It will also be necessary to assess unintentionally produced organic pollutants such as brominated dioxins and furans (Hamm & Strikkeling et al. 2001; Tasaki & Takasuga et al. 2004; Hirai & Sato et al. 2008) as part of this review.

In cases where treatments include recycling consideration has to be given to the risks associated with the release into products of PBDE containing materials throughout the entire lifecycle of those products. This includes an assessment of possible exposure to workers involved in reprocessing, users of recycled materials and the range of exposures which arise from the end of life of the recycled materials. Consideration needs to be given to the possibility of labeling such materials to avoid inadvertent contamination in the future. Industries treating material which may be contaminated by PBDEs (metal smelters, incinerators or cement kilns etc.) need to be alerted to the hazardous nature of the materials and guidance needs to be prepared to ensure that wastes are treated using environmentally sound methods.

One important issue which needs to be clarified is the level of PBDE contamination above which a material should be regulated by the Stockholm Convention. This question is crucial for several issues which have to be addressed for the SC implementation. For PCB and (POPs Pesticides) the current provisional low POPs limit recommended by the Open Ended Working Group of the Basel Convention (Basel Convention 2004) and which is being used pending the determination of a methodology to establish final levels is 50 ppm (and for PCDD/PCDF the limit is 15 µg TEQ/kg).

No low POPs content has yet been developed for PBDEs. One existing limit for PBDE in goods is that defined by the European RoHS regulation for electrical and electronic equipment and currently at 0.1% for PentaBDE, OctaBDE and DecaBDE (Cusack & Perrett 2006). When comparing this limit with the limit for e.g. PCB the limits seems too high and it seems likely that a lower 'low POPs' limit will need to be defined for PBDE.

Furthermore whilst brominated dioxins and furans may be responsible for much of the health and environmental risk associated with the use of PBDEs (Hirai & Sato et al. 2008) no limits have been defined for PBDD/PBDFs yet. Indeed they are not yet Stockholm POPs and are not currently being considered by the POP Review Committee. Only the German law on chemical (German Federal Ministry of Justice 2003) has defined a limit for PBDD/PBDF in products (table 1).

Compd class	Compounds	Limits
Class I	2,3,7,8-TBDD, 2,3,7,8-TBDF, 1,2,3,7,8-PBDD, 1,2,3,7,8-PBDF	Sum class I < 1 µg/kg
Class II	1,2,3,7,8-PBDF, 1,2,3,6,7,8-HBDD, 1,2,3,7,8,9-HBDD, 1,2,3,4,7,8-HBDD	Sum (I + II) < 5 µg/kg

Table 1: Limit value for polybrominated dibenzodioxins and dibenzofurans in materials according the German regulation for chemicals (German Federal Ministry of Justice 2003).

Low POPs limits for PBDE (and PBDD/PBDF) should be derived based on risk assessment and considerations for minimization of releases of POPs. The process should involve or better be guided by scientific discussions and assessments and be based on scientific criteria. In the development of a low POPs content of PBDE the scientific POPs community should therefore be an important stakeholder.

In addition there would be further research issues in the context of PBDE which might be taken up by the global POPs research community:

- Screening on contamination levels of PBDE and other critical pollutants in the recycling flow and their human exposure, final sink and phase out options
- A global substance flow analysis for PBDE and other critical pollutants
- Further data on (human) toxicity for PBDE and related risk assessment

The case of PBDE is another example of where inadequate evaluation of a halogenated chemical prior to large scale production and use has resulted in global pollution. Residual contamination of a wide range of product streams and the difficult challenges, and high economic costs, are now apparent in relation to the recyclability of

several waste streams. These chemicals even impact on the recycling of other non-contaminated products in the plastics waste stream. It is clear that chemicals used now and in future for flame retardancy need a much more rigorous evaluation over their whole life cycle. In this respect a report for the European Commission on the extension of the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (Groß & Bunke et al. 2008) proposed the phase out all brominated and chlorinated flame retardants along with PVC and heavy metals in electric and electronic consumer to protect consumers and to facilitate easier and safer recycling at the end of life stage (European Commission 2010).

In addition to the evaluation required for REACH, the science community could critically evaluate currently used and emerging flame retardants to bridge the knowledge gap for these bulk chemicals which are in daily products with direct exposure to consumers. This assessment should include considerations on interaction of chemicals in chemical mixtures having in mind the increasing range of BFRs and other PBTs which are included in products but which are not adequately considered by REACH (Rudén & Hansson 2009). This approach should help to avoid repeating the mistakes of the recent past.

If independent science assists a better understanding of the hazards associated with these compounds and results in increased substitution by more benign chemicals, then PBDEs could serve as examples of the benefits of the phase-out of halogenated chemicals from use in consumer products. More positive application and integration of the principles of substitution and precaution would not only guarantee reduced life cycle costs and improved recycling with associated economic benefits but would also reduce risks of damage to health and the environment over the whole life cycle of a product. This would be an important contribution to sustainable production and consumption.

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